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David J. Blacker

Raimondo Fazio

Claire Tucak

Phillip Beranek  
*Edith Cowan University*

Connor Pollard  
*Edith Cowan University*

*See next page for additional authors*

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## Authors

David J. Blacker, Raimondo Fazio, Claire Tucak, Phillip Beranek, Connor Pollard, Tegan Shelley, Sanathraj Rajandran, Georgina Holbeche, Mitchell Turner, and Travis Cruickshank

## ORIGINAL ARTICLE



# FIGHT-PD: A feasibility study of periodized boxing training for Parkinson disease

David J. Blacker MBBS, FRACP<sup>1</sup> | Raimondo Fazio<sup>2</sup> | Claire Tucak BSc<sup>3</sup> | Phillip Beranek<sup>4</sup> | Connor Pollard<sup>5</sup> | Tegan Shelley<sup>5</sup> | Sanathraj Rajandran<sup>6</sup> | Georgina Holbeche PhD, BA<sup>2</sup> | Mitchell Turner<sup>4</sup> | Travis Cruickshank<sup>7</sup>

<sup>1</sup>Perron Institute for Neurological and Translational Science, Dept of Neurology, Sir Charles Gairdner Hospital, University of Western Australia, Nedlands, Australia

<sup>2</sup>Perron Institute for Neurological and Translational Science, Nedlands, Australia

<sup>3</sup>Department of Physiotherapy, Sir Charles Gairdner Hospital, Perron Institute for Neurological and Translational Science, Nedlands, Australia

<sup>4</sup>Centre for Precision Health, Edith Cowan University, Joondalup, Australia

<sup>5</sup>Edith Cowan University, Joondalup, Australia

<sup>6</sup>University of Western Australia, Nedlands, Australia

<sup>7</sup>Centre for Precision Health, Edith Cowan University, Perron Institute for Neurological and Translational Science, Nedlands, Australia

## Correspondence

David J. Blacker, Perron Institute for Neurological and Translational Science, Dept of Neurology, Sir Charles Gairdner Hospital, University of Western Australia, 8 Verdun St, Nedlands, 6009, Western Australia, Australia. Email: [davidblackermid@hotmail.com](mailto:davidblackermid@hotmail.com)

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## Abstract

**Background:** Boxing training has become a popular form of exercise for people with Parkinson disease (PD). There is a dearth of high-quality feasibility, safety, and efficacy data on boxing training for PD. Feasibility of Instituting Graduated High-intensity Training (FIGHT-PD) aimed to examine these features in a periodized boxing training program featuring high-intensity physical and cognitive demands.

**Objective:** To conduct a feasibility study, aiming to address deficiencies in the current knowledge base and to provide data for future studies.

**Design:** Single-arm, open-label feasibility.

**Setting:** University department and medical research institute.

**Participants:** Ten people with early stage PD without contraindications to intense exercise, identified from a database of participants interested in boxing training.

**Interventions:** A 15-week exercise program with three 1-hour sessions per week, with each session including warmup and then rounds of noncontact boxing using a training device. Three distinct blocks of 5 weeks including active rest.

1. Boxers Development: focus on training technique
2. Boxers Cardio: increasing intensity, including high-intensity interval training
3. Boxers Brain: focus on cognitively challenging dual task training

**Main Outcome Measures:** Process, resource, and management measures including recruitment and retention rates, timelines and costs, and compliance with prescribed exercise targets. Clinical outcomes were safety (adverse events), training intensity (using heart rate and perceived exertion monitoring), tolerability (pain, fatigue, and sleep scores), and pre- and postprogram Unified Parkinson Disease Rating Scale (UPDRS-III).

**Results:** Among 10 participants from a pool of 82 (recruitment rate = 12%), there were no withdrawals; 348/360 workouts were completed (adherence = 97.7%); 4/348 (1.1%) workouts were missed due to minor injury. Nine of 10 participants showed improvement in UPDRS motor score.

**Conclusions:** FIGHT-PD provides a depth of feasibility and safety data, methodological detail, and preliminary results that is not described elsewhere and could provide a useful basis for future studies of boxing training for PD.

## INTRODUCTION

Boxing training has become a popular form of exercise for Parkinson disease (PD).<sup>1–8</sup> Several commercial noncontact boxing exercise training programs exist, including Rock Steady Boxing, which boasts more than 4500 members worldwide.<sup>9</sup> Although these programs are popular, evidence supporting their feasibility is limited and largely descriptive.

In a recent systematic review, Morris et al.<sup>9</sup> noted low-level evidence supporting the implementation of boxing training as therapy for PD. It was noted existing literature provided minimal detail on important study and intervention elements such as description of the programs including equipment, staffing, tailoring, and progression of the program to the needs and disease state of individuals. Based on these methodological concerns, the authors stressed a need for trials aimed at robustly establishing the feasibility and efficacy of boxing training. The authors emphasized a need for greater detail on boxing training programs to help facilitate scientific appraisal and interpretation of findings.

More recently, Domingos et al.<sup>10</sup> provided greater detail, describing the composition and specific exercises prescribed in a boxing training program with and without kicking. This study did not detail the intensity of training sessions with rates of perceived exertion (RPE) or heart rate (HR) monitoring and did not report compliance.

These limitations motivated our team to undertake a 15-week feasibility study of periodized boxing training for people living with PD; the **F**easibility of **I**nstituting **G**raduated **H**igh intensity **T**raining (FIGHT-PD). The program was designed to help ensure participant safety, maximize training benefits, avoid monotony<sup>11</sup> and associated participant dropout, and allow for an independent examination of training blocks. We made an exercise prescription for all workouts based on physical (RPE)<sup>12</sup> and mental (RPME) rates of exertion and measured compliance using HR monitoring. An important threshold was 80% of age-predicted maximum HR (APMHR), which has been used to define high-intensity exercise in several important phase II studies<sup>13–15</sup> of exercise for PD. To enable reproducibility, FIGHT-PD provides detail on the intervention delivered and measures used to evaluate its feasibility and preliminary utility.

## METHODS

### Study design

The present study was a single-arm, open-label, study of the feasibility of periodized boxing training for people with PD.

## Participants and population

Ten participants with idiopathic PD were identified from a preexisting PD database, contacted by telephone, and screened for eligibility according to the following criteria:

Inclusion: (1) established diagnosis of PD, (2) willingness to participate in a boxing training program, and (3) Hoehn and Yahr scale score of 1 or 2.

Exclusion: (1) cognitive impairment prohibiting the ability to follow complex commands (Montreal Cognitive Assessment [MoCA] < 24), (2) poorly controlled cardiovascular or respiratory disease preventing safe engagement in boxing training sessions, (3) uncontrolled hypertension >160/90, (4) negative chronotropic medications (eg, beta-blockers), and (5) musculoskeletal conditions that would be exacerbated by boxing training. Participant recruitment details are presented in Figure 1.

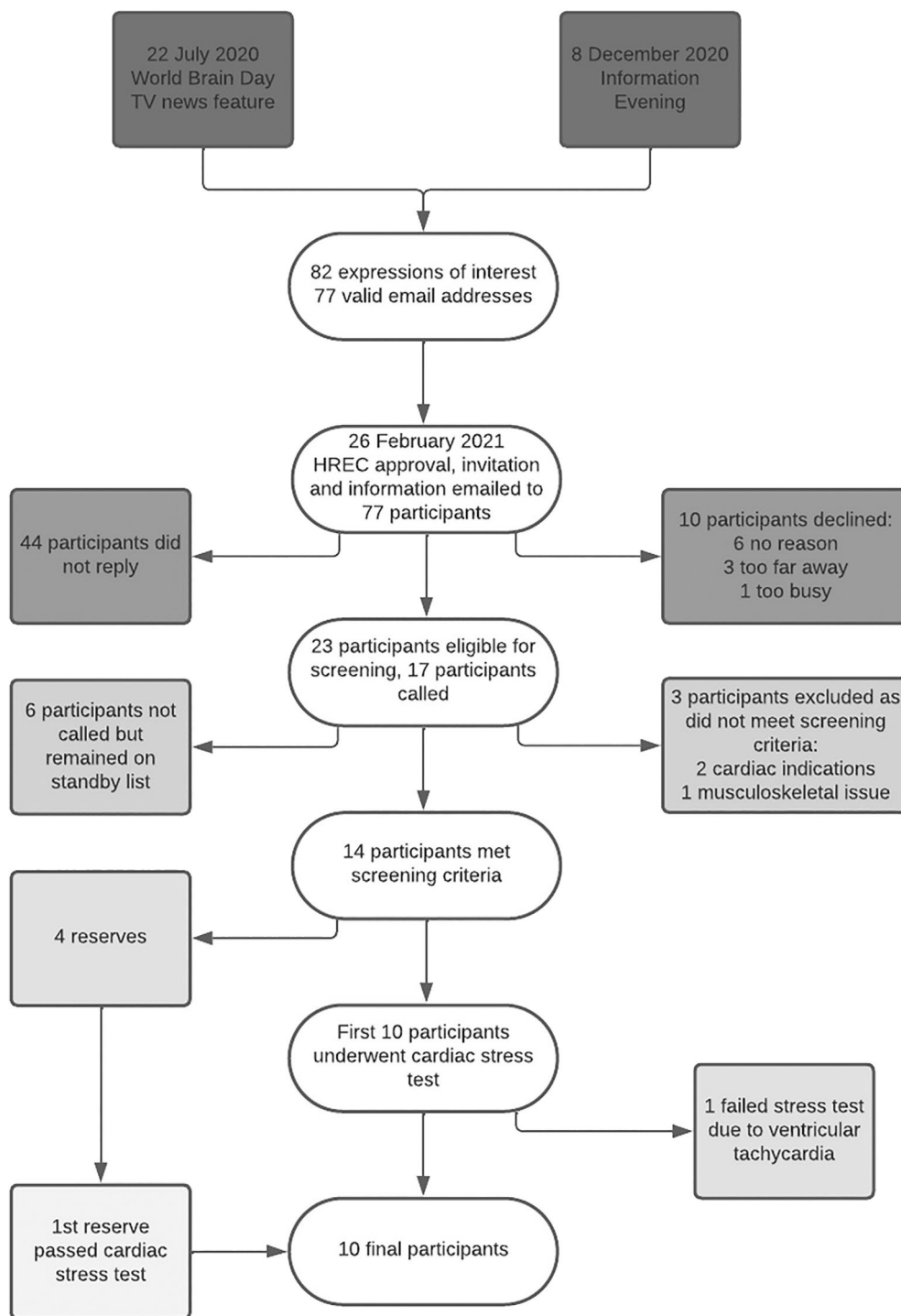
The training group size of 10 participants was chosen to enable at least one staff member to supervise no more than two participants (to ensure participant safety). This also complied with physical distancing requirements during the COVID-19 pandemic, which resulted in state border closures between March 24, 2020 and March 3, 2022. Screening commenced on March 3, 2021 and the final contact with participants was on September 23, 2021. A local COVID “lockdown” from June 28 to July 2, 2021 coincided with a planned rest week between training blocks one and two.

## Study intervention

The FIGHT-PD intervention was developed by a multidisciplinary team consisting of a professional boxing coach, experienced neurologist living with PD,<sup>16</sup> exercise physiologists, and a physiotherapist. A detailed description of the FIGHT-PD noncontact boxing training program is provided in the Supplementary Material. A synopsis is presented here and an overview is illustrated by Figure 2.

The intervention was delivered in person in a group format three times per week over a 15-week period by a professional boxing coach using the FIGHTMASTER boxing unit device (Land America Fitness Company, Xiamen, China). The FIGHTMASTER (see Supplementary Material Figure 1) is a commercially available boxing training device that comprises 11 padded punching targets on a resistant stand. The targets are numbered and adjustable and therefore accommodate for differing anthropometrics and disability.

Before commencing the intervention, a 2-hour orientation session was provided to familiarize participants with logistical aspects and emphasize safe training and injury avoidance. Continual HR monitoring was undertaken using a commercial HR monitoring system



**FIGURE 1** Participant flow, CONSORT diagram. CONSORT, Consolidated Standards of Reporting Trials; HREC, Human Research Ethics Committee

with a sensor chest strap “bluetoothed” to each participant’s phone. Participants were instructed on physical (RPE)<sup>12</sup> and mental (RPME) scales, which were used to prescribe and monitor target training loads. Participants verbalized their estimate of RPE and RPME, which was recorded contemporaneously by exercise physiologists. These data and HR data were uploaded at the end of each workout and used to evaluate compliance to the prescribed boxing training.

Exercise physiologists assisted with delivery and monitored compliance to prescribed boxing training sessions. Training sessions were undertaken in a biomechanics laboratory with softer flooring to mitigate injuries from repetitive impact or falls.

Each workout was standardized and consisted of:

1. A boxing-specific warmup, approximately 10 minutes: a sequence of rotational movements of major muscle

	Familiarization Week														
	Training Weeks														
	Rest Week														
Training Program	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
	Boxers Development					Boxers Cardio					Boxers Brain				
	Physical Load		Cognitive Load			Physical Load		Cognitive Load			Physical Load		Cognitive Load		
	<70% APMHR <13 RPE		<7 RPME			>80% APMHR >15 RPE		<7 RPME			70-80% APMHR 13-15 RPE		>7 RPME		
Example Block	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12			
	UB	C	LB	CA	CA	Boxing									
	Boxers Movement														

**FIGURE 2** Description of training blocks and exercise prescription. APMHR, age-predicted maximum heart rate; C, core; CA, cardio; LB, lower body; R, round; RPE, rate of perceived exertion; RPME, rate of perceived mental exertion; UB, upper body; W, week

groups and joints was performed at the start of each workout.

- Boxing-specific movements and aerobics, approximately 10 minutes: A combination of traditional 'boxers' movements were modified to suit the capabilities of each participant. Differing boxing stances and movements were used to promote balance. Aerobic exercises and a series of boxing drills were performed to increase cardiovascular load.
- Boxing sequences, approximately 25 minutes: Boxing sequences were undertaken using the FIGHTMASTER unit and consisted of unidirectional and bidirectional punches that included jabs, hooks, and uppercuts directed at the numbered pads. Each sequence took approximately 10–15 seconds to complete and was repeated for a 2 to 3 minute "round," with no more than 2 minutes rest between rounds.

Intensity was adjusted in each of these three components of individual workouts by adjusting number and speed of repetitions, use of more vigorous exercise (eg, "star jumps") to increase intensity, and the addition of more boxing rounds during block two and more cognitive tasks in block three.

The boxing training intervention was organized into three distinct training blocks: boxers' development, boxers' cardio, and boxers' brain. Each block consisted of familiarization (week 1), training (weeks 2–4), and rest phases (week 5). The composition and intensity of training blocks are outlined in the supplementary material.

### Boxers' development (training block 1)

The aim was to introduce participants to the workout, focusing on the fundamentals of technique performed at low speed and low to moderate intensity. Participants were instructed in the specific movements required to make individual punches (eg, straights, hooks, uppercuts) and then how to combine these in sequences. Trainers directed participants to concentrate on technique and keep within the prescribed RPE target.

### Boxers' cardio (training block 2)

Boxers' cardio was designed to improve cardiovascular fitness and ultimately achieve high-intensity interval training, which is considered bursts of near maximal effort interspersed with rest periods.<sup>17</sup> Short bursts (10–15 s) of near maximal effort with "flurries" of punches (usually uppercuts) were added to the rounds of boxing, with trainers encouraging efforts to the end of each round. The number of rounds was increased from 6 at the start of week one to 11 by the end of week four.

### Boxers' brain (training block 3)

Boxers' brain was designed to increase cognitive demands during boxing sequences. Participants were cognitively challenged by suddenly undertaking random,



previously not performed punching sequences and having to memorize sequences of between five to nine different punches. Participants were asked not to compromise the accuracy and speed of boxing movements with the introduction of cognitive tasks. The physical intensity target was reduced to 70%–80% APMHR and the RPE to 13–15 to allow for the mental challenge and maintenance of correct, safe technique.

## Primary outcome

The primary outcome for this study was the feasibility of the prescribed periodized boxing training for people with early-stage PD. Feasibility was evaluated according to Learmonth and Motl<sup>18</sup> and involves the measurement of the process, resources, management, and scientific validity. Components included:

*Assessment of process feasibility*, which involved examination of recruitment and retention rates (eg, the response to recruitment strategies, percentage of individuals who remained interested in participating following presentation of study information, percentage eligible following eligibility screening).

*Examination of resource feasibility*, which involved assessment of participant retention rates, communication methods used for contacting participants, monetary costs associated with the intervention (ie, cost of equipment), and adherence to boxing training sessions (prescribed versus attended boxing training sessions).

*Management feasibility*, which involved assessment of ethics and trial registration processes (timelines and amendments to the study protocol), time commitment for research personnel (time taken for database development, participant recruitment, assessment administration, intervention design and delivery, data entry and quality checking, follow-up of missing data).

*Scientific feasibility*, which involved examination of:

1. Safety by monitoring adverse events, and pain/discomfort (using the Borg Pain and Discomfort Scale<sup>12</sup>). This was reviewed at each workout, with the intent being to prevent injury.

2. Tolerability by measuring fatigue (using visual analogue scale of the Fatigue Severity Scale<sup>19</sup>) and sleep health (using the Satisfaction Alertness Timing Efficiency Duration Scale,<sup>20</sup>).

3. Compliance to boxing training, that is, prescribed versus completed boxing training sessions at a given physical (ie, HR and RPE) and mental intensity (ie, RPME) target.

4. Treatment effects by measuring Unified Parkinson Disease Rating Scale (UPDRS-III) scores before and after.

5. Experience and burden by asking two questions at the completion of the study

1. Please describe any issues that made participation difficult (barriers).

2. Please describe any issues that encouraged participation (enablers).

## Statistical analysis

Python (version 3.6) was used to perform statistical analyses. Data were checked for normality using the Shapiro–Wilks test, with parametric and nonparametric analyses applied where appropriate. Descriptive statistics, including percentage, mean, and range, were calculated for process, resource, and management feasibility components. The safety, tolerability, and compliance outcomes were assessed for each training. Kruskal–Wallis tests were used to assess variance between the three training blocks for each of these scientific feasibility outcomes. Mann–Whitney U tests used to identify specific differences, if required. Significance was set at  $p < .05$ .

## RESULTS

### Participant demographics and clinical characteristics

Demographics and clinical characteristics are presented in Table 1. There were six males and four females. The mean age of participants was 60 years. Hoehn and Yahr scores varied between 1 ( $n = 8$ ) and 2 ( $n = 2$ ), respectively. One participant recorded a MoCA of 22 (with short-term recall issues) but was not excluded from the trial because they were able to demonstrate sufficient comprehension and understanding to provide consent.

### Primary outcome

#### Process feasibility; recruitment

Participant flow for the FIGHT-PD trial is presented in Figure 1. Eighty-two individuals expressed interest in participating and were contacted by email. Five (6%) had invalid email addresses and were unable to be contacted. Forty-four (54%) did not respond to the email. Ten (12%) individuals declined participation. Twenty-three (28%) wished to participate in the trial. Seventeen (21%) underwent telephone screening. Three (4%) were excluded due to cardiac and musculoskeletal contraindications. Of the 14 individuals who met eligibility, 11 (13%) underwent cardiac stress testing. One failed the cardiac stress testing due to ventricular tachycardia. The remaining 10 were included in the FIGHT-PD trial. The recruitment rate using this methodological approach was 12%; however, a surplus of individuals expressed interest in the study.

TABLE 1 Participant demographics and characteristics

Participant	Age	Weight	Height	MoCA	UPDRS		BP sitting	BP standing	Symptoms onset	Diagnosis date	Date of first medication	Medication	PD subtype	Predominant sidedness	H & Y stage
					(motor score)										
FPD1-001	65	87	179	30	25		175/86	133/83	2008	2010	2010	Pramipexole, Stalevo	Tremor	Right	2
FDP1-002	45	79	180	26	6		137/80	135/87	2015	2016		Stalevo, Rotigone	Tremor	Left	1
FDPI-003	52	100	182	22	25		169/94	137/76	2019	2020	2020	Pramipexole	Tremor	Left	1
FPD1-004	65	60	165	30	24		149/91	136/95	2016	2018	2000	Madopar	PIGD	Left	2
FPD1-005	66	65	154	28	18		140/83	123/85	2016	2018	N/A	Nil	PIGD	Left	2
FPD1-006	63	87	183	29	32		170/93	131/82	2017	2020	2020	Rasagaline	Tremor	Left	1
FPD1-007	67	73	167	29	15		155/95	144/80	2014	2015	2015	Madopar, Pramipexole	PIGD	Right	1
FPD1-008	56	73	175	30	14		117/81	88/71	2017	2018	2018	Madopar	Tremor	Right	1
FPD1-009	56	82	183	29	7		128/88	127/88	2018	2019	2019	Stalevo, Safinamide	PIGD	Right	1
FPD1-010	65	81	183	30	10		125/90	130/94	2018	2019	2019	Madopar, Pramipexole	PIGD	Right	1

Abbreviations: BP, blood pressure; FPD, familial Parkinson disease; H & Y, Hoehn and Yahr; MoCA, Montreal Cognitive Assessment; PD, Parkinson disease; PI GD, postural instability and gait disorder; UPDRS, Unified Parkinson Disease Rating Scale.



## Resource feasibility: retention, adherence, costs associated with the study, and communication

No participants withdrew from the study (100% retention), and all assessment procedures were completed. Adherence was excellent, with 348 out of a possible 360 (96.7%) training sessions completed. Two missed a total of four workouts due to injury (see safety and adverse events section). Four workouts were missed for reasons related to the COVID pandemic (one participant was unwell after a vaccination, and three missed due to scheduling issues related to lockdowns). The remaining four were for miscellaneous reasons.

### *Communication time and methods*

Telephone screening procedures were approximately 30 minutes in duration. The period from telephone screening to cardiac stress testing averaged 17.7 days, (range 13–22 days). Baseline testing procedures took an average of 13.1 days (range 1–22 days) to complete following eligibility confirmation (ie, screening and negative cardiac stress test). The time from expression of interest on World Brain Day (July 22, 2020) to commencement of FIGHT-PD training sessions (May 19, 2021) was 301 days. Participants were contacted via SMS and using WhatsApp.

### *Monetary requirements*

The total cost of the study was \$53,949 (mean cost per person = \$5394.90). Study personnel cost \$29,200 including intervention design and pilot testing, equipment and setup, database creation, participant recruitment, assessment administration, intervention delivery and recording, and data entry and checking activities. Cardiac stress testing was \$6171 (mean cost per person = \$617). Equipment costs, including FIGHT-MASTER boxing units (per person = \$1700), polar heart rate monitors (per person = \$100), boxing gloves (per person = \$35) and wrist straps (per person = \$12) were \$18,470. Miscellaneous expenditures for sterilization wipes (for equipment; per pack = \$10), food (fruit and lollies; \$42) and training booklets (per booklet = \$3.60) were \$108.

## Management feasibility; data management and safety

### *Ethical approval and trial registration*

Ethical approval took 126 days and involved two revisions. No amendments were made to the trial following ethical approval. Time to receive approval from the Australian New Zealand Clinical Trials Registry was 165 days.

### *Research personnel time requirement*

Research activities were undertaken in kind by study investigators. Time taken to complete the study was

425 hours and involved the following activities: development and piloting of the boxing training program (120 hours), equipment ordering and setup (15 hours), database creation (8 hours), assessment preparation (16 hours; hardcopy and electronic), participant recruitment (20 hours; invitation letter, emailing, phone calls), administration of assessments (20 hours), intervention delivery and recording (135 hours; scheduling of training sessions, sterilization of equipment, delivering training sessions, and monitoring intervention adherence and compliance), and data entry and checking (37 hours).

### *Missing data*

Forty-six training sessions had missing HR data (HR data captured for 302 out of a possible 348 training sessions [86.8%]) due to Bluetooth synchronization failures and participants failing to initiate HR recordings (via the Polar Beat application). Tolerability data were captured for 338 assessments out of a possible 348 assessments [97.1%]. Missing data were attributed to participants forgetting to complete session tolerability assessments. There were no missing data for RPE and RPME measures.

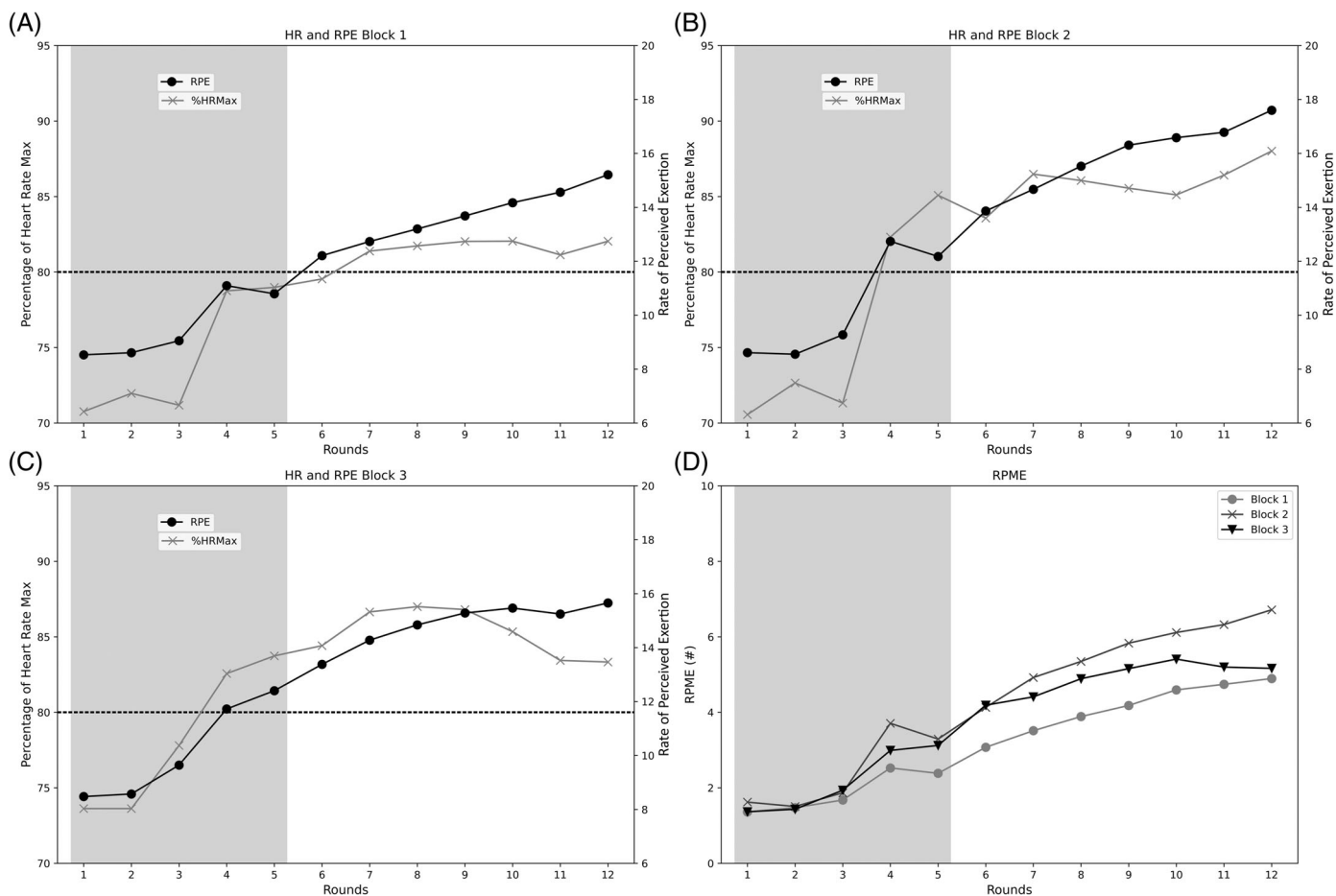
## Scientific feasibility; safety, burden, and treatment effect

### *Safety and adverse events*

One serious adverse event occurred during the study. One participant was hospitalized due to an overdose of medications and alcohol. After assessment by the participant's usual physician, participation was resumed, missing one workout. Four of 348 workouts were missed due to minor injuries; one participant strained a calf muscle and missed three workouts, another exacerbated a preexisting knee injury, missing one workout. Two reported foot pain during the study, which resolved through changing footwear and supplying a cushioned floor mat.

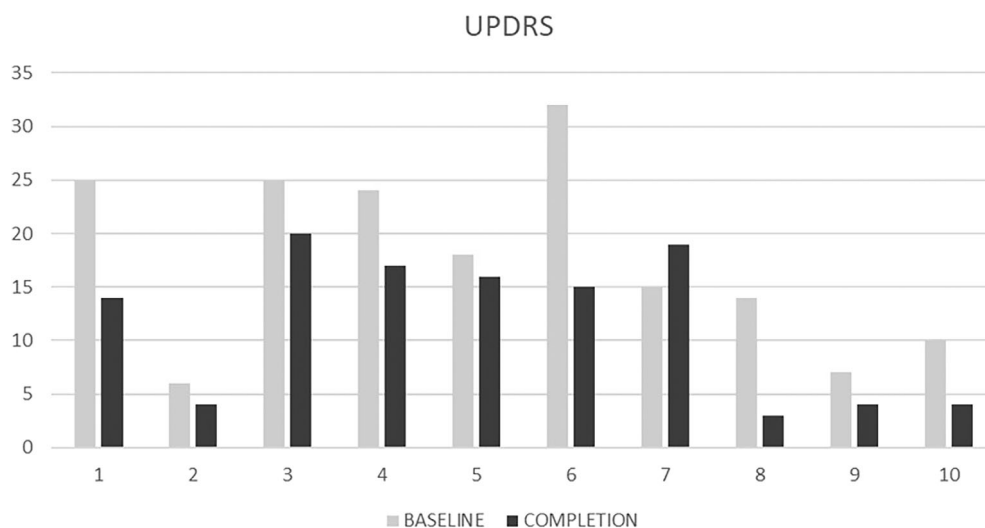
### *Compliance*

Participants complied with the prescribed physical intensity (as indicated by HR) of boxing training in 6.7% of sessions in block 1, 64.5% of sessions in block 2, and 34.4% of sessions in block 3, respectively (see Figure 3). There was a tendency to exceed prescribed physical intensity zones. In block 1, the target was <70% APMHR; with 93.3% of participants exceeding this value. In block 3 the target range was 70%–80%; 6.4% fell below this and 59.2% exceeded this. Compliance to the prescribed mental intensity of boxing training occurred in 99.1% of rounds in block 1, 99.0% of rounds in block 2, and 15% of rounds in block 3 (see Figure 3).



**FIGURE 3** Participant average heart rate and rate of perceived exertion data for each round indicated by red and blue lines for training blocks one (A), two (B), and three (C). Dotted line represents the 80% of percentage heart rate max. Participant rate of perceived mental exertion data (D) for each round of each training block. Gray shaded area represents the warmup rounds for each training session. HR, heart rate; RPE, rate of perceived exertion; RPME, rate of perceived mental exertion

**FIGURE 4** Participant UPDRS motor values before and after FIGHT-PD intervention. Abbreviations: FIGHT-PD, Feasibility of Instituting Graduated High-intensity Training-Parkinson Disease; UPDRS, Unified Parkinson Disease Rating Scale



### Tolerability

A significant reduction in self-reported fatigue was observed between blocks 1 and 3 ( $p = .018$ ) and 2 and 3 ( $p = .043$ ), respectively. An improvement in

sleep health was observed between blocks 1 and 3 ( $p = .001$ ) and 2 and 3 ( $p = .018$ ), respectively. No significant changes to self-reported pain/discomfort were observed between training blocks

1 (14.50 [2.00, 40.00]), 2 (14.50 [1.78, 51.88]), or 3 (6.00 [2.40, 53.00]).

### *Experience/Burden*

Barriers to participation included the long travel distance required to undertake boxing training sessions (noted by five), difficulty accessing toilets near boxing training sessions (two), the firmness of the training floor (one), and workplace perceptions that boxing is inappropriate for women (one). Motivators included camaraderie in the group and positive relationships formed with other participants. One participant indicated that weight loss and better blood lipids profiles were also motivating factors.

### *Treatment effects (UPDRS motor)*

Although group-level statistics were not significant ( $>.05$ ), all but one participant showed a reduction in UPDRS motor score (ie, improvement; Figure 4).

## DISCUSSION

This study evaluated process, resource, management, and scientific feasibility of periodized boxing training for people living with PD. The FIGHT-PD boxing training program was found to be feasible and safe.

The recruitment rate was 12%; although low, this enabled the recruitment of 10 participants for the purposes of examining feasibility. Earlier studies<sup>3,21</sup> have shown higher recruitment rates of 60% and 68%. The lower recruitment rate in FIGHT-PD might be attributed to the study being undertaken during the COVID-19 pandemic, when restrictive public health measures were applied.

Adherence (96.7%) and retention (100%) rates for the study were high, indicating the intervention was acceptable for people with PD. Despite a number of studies exploring boxing training for people living with PD, only two have reported data on training adherence and participant retention. Sangarapillai et al.<sup>8</sup> examined the utility of boxing training compared to a sensory exercise program and reported similar adherence (98%) and retention (100%) rates to the present study. Domingos et al.<sup>10</sup> investigated boxing training with and without kicking exercises and also noted high adherence (85%). This study, however, reported lower retention (86%) than the present study and work by Sangarapillai et al.<sup>8</sup> It is noteworthy that FIGHT-PD and work by Sangarapillai et al.<sup>8</sup> included high-intensity boxing training sequences and reported no serious adverse events. Throughout the intervention, tolerability data indicated no adverse changes in muscle soreness, a reduction in fatigue, and improvements in sleep. The improvements in sleep align with a recent investigation that noted positive effects on sleep quality and daytime sleepiness following boxing training.<sup>22</sup>

These findings suggest that boxing training interventions, including high-intensity components, are well tolerated and safe for people with PD.

Compliance to the exercise prescription was recorded by HR monitors and RPE scales. To our knowledge, this was the first study to capture data on compliance, with most studies capturing only data on adherence to training. HRe data were captured for 302 of 348 sessions, with missing data attributed to Bluetooth connectivity and initializing issues. The RPE data were captured for all sessions. Compliance varied considerably between blocks. Low to moderate compliance was observed for physical intensity zones prescribed for blocks 1 (6.7%), 2 (64.5%) and 3 (34.4%). Participants tended to exceed the physical intensity zones prescribed. This was particularly evident for blocks 1 and 3 and suggested that the prescribed physical intensity zones were too low for the recruited sample. This could indicate a degree of conservatism by study investigators with respect to training zone prescription or that participants were more active than anticipated.

We detail the cost, personnel, and communication required to deliver this study. The cost of delivering FIGHT-PD was \$53,949, equating to \$5394.90 per participant. This reflects direct and indirect expenses considered startup activities, including intervention development and piloting, which have not been reported by existing boxing training studies. The cost is higher than a previous study<sup>23</sup> of a 10-week balance program for people with PD that estimated the cost per participant to be \$2490. This did not consider startup activities, including intervention development and piloting, as part of expenses. FIGHT-PD was considerably more costly to deliver. We attribute this to the staffing, resources, approvals, and procedures required to conduct this study safely during the COVID-19 pandemic.

Barriers to boxing training included travel distance, accessibility of toilets, and floor firmness. Motivators to boxing training included camaraderie and positive relationships formed with fellow participants. These social benefits cannot be understated, particularly given the link between socialization and emotional well-being.<sup>24,25</sup>

Mean improvements in UPDRS motor values were observed in the current study; however, improvements were not significant, presumably owing to the small sample of participants. This finding contrasts previous work by Sangarapillai et al.,<sup>8</sup> who noted worse UPDRS values in individuals with PD following a 10-week Rock Steady Boxing training program. Additional phase II clinical trials are needed to definitively determine the effects of boxing training on UPDRS values in people with PD.

## Study limitations

This study has several limitations. Exercise history and measures of fitness and strength were not examined

before study commencement and may explain participants exceeding the prescribed physical intensity of training blocks. This study included only individuals with early-stage PD and involved close supervision of training. Findings may therefore not be generalizable to people with more advance stages of PD or applicable in community settings where close supervision is not possible.

## Conclusions

FIGHT-PD investigated, for the first time, the feasibility of periodized boxing training for people with early PD. The boxing program was found to be safe, well tolerated, and acceptable for people living with early-stage PD. We consider that the FIGHT-PD boxing training program can be moved to a formative evaluative phase where the therapeutic effects of the intervention can be evaluated, particularly on outcomes of disease progression.

## STUDY APPROVAL, REGISTRATION, AND CONSENT

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was granted by the University of Western Australia (2020/ET000050) and Edith Cowan University (2021-02330). Participants provided written informed consent, obtained by the senior study physician, before study commencement. The study was registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12621000143820); [anzctr.org.au](http://anzctr.org.au).

## SCIENTIFIC MEETING PRESENTATIONS

The background and FIGHT-PD protocol have been presented to The Australian and New Zealand Association of Neurologists annual meeting, May 20, 2021; conference abstract 61 published in *BMJ Neurol Open* 2021;3 (Supp 1):A22, and also to the Movement Disorders international virtual meeting, September 2021; abstract number 368 published in *Movement Disorders* 2021, Vol 36, supp1, S162.

The results were presented to the Australian and New Zealand Association of Neurologists annual meeting, May 11, 2022; abstract publication pending.

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## DISCLOSURES

Raimondo Fazio holds a patent for the FIGHTMASTER training device. The boxing training program detailed within the manuscript is currently being considered as a commercial intervention for people with Parkinson disease. David J. Blacker reports honoraria from Seqiris Therapeutics; Chair of Clinical Advisory Committee, Argenica Therapeutics (medical monitor for a phase I study of R18); and stock options in Argenica Therapeutics.

## ORCID

David J. Blacker  <https://orcid.org/0000-0003-0046-9776>

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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